Sediment Budget Analysis System for ArcView (SBAS-A)

Lecture	SBAS-A Overview
Exercise A	Creating Littoral Cells
Exercise B	Creating Flux Layers
Exercise C	Determining Values for Cells and Fluxes
Exercise D	Calculate Volume Difference per Littoral Cell
Exercise E	Entering Values to Cells
Exercise F	Entering Values to Fluxes
Exercise G	Creating Macro Budgets
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Module Introduction

Overview

A comprehensive Geographic Information System (GIS) enables its users organize, develop and maintain various types of coastal data and resources. GIS provides the tools necessary for spatial data analysis. The purpose of this module is to instruct all levels of GIS users on the processes needed to compute values for a sediment budget in the ArcGIS 9.0 environment.

Skills Learned

Using SBAS-A users will be able to create a Regional Sediment Budget within ArcGIS.

Tools and Technology

ArcGIS Components

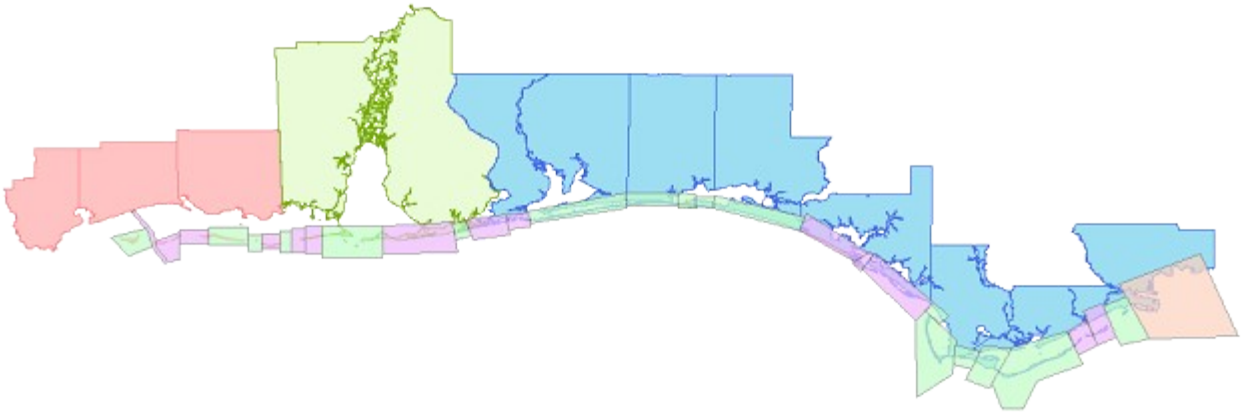
- ArcMap

ArcGIS Extensions

- Sediment Budget Analysis System for ArcView (SBAS-A)
- Spatial Analyst
- 3D Analyst

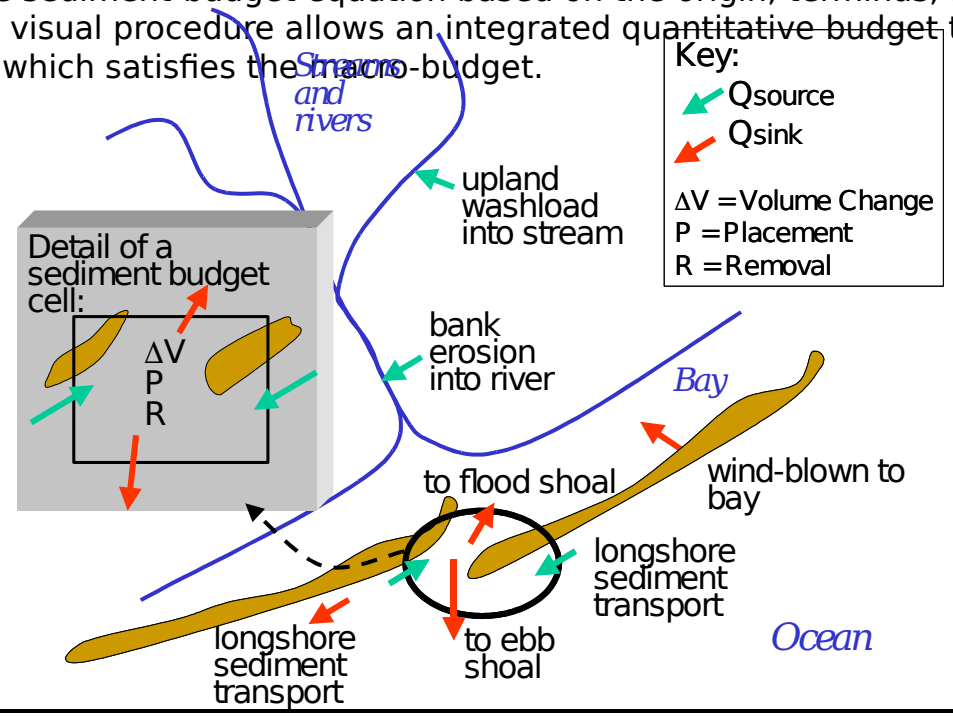
Sediment Budget Purpose

- The importance of a sediment budget lies in the ability to assist in identifying longshore sediment transport rates, sediment patterns and pathways, areas of erosion and accretion, and understanding beach and bathymetry change over the region.
- Regional impacts resulting from modifications to site-specific projects can be identified. Thus, the purpose of the Regional Sediment Management study.



Sediment Budget Analysis System - OVERVIEW

The **Sediment Budget Analysis System** (SBAS) provides a framework for formulating, documenting, and calculating sediment budgets, including estimation of uncertainty, hence the reliability of the budget. SBAS allows representation of multiple inlets within a sediment budget that can be local or regional. The model formulates a sediment budget by allowing the user to create a series of cells and arrows representing sources and sinks which characterize the conceptual budget. Sediment budget cells, arrows expressing directions of net, east-, and west-directed transport rates, and notation of P and R values comprise what is called the sediment budget topology. SBAS automatically formulates and substitutes these quantities into the sediment-budget equation based on the origin, terminus, and direction of arrows representing rates. This visual procedure allows an integrated quantitative budget to be formed based on the conceptual budget, which satisfies the mass-balance budget.



Creating a Regional Sediment Budget

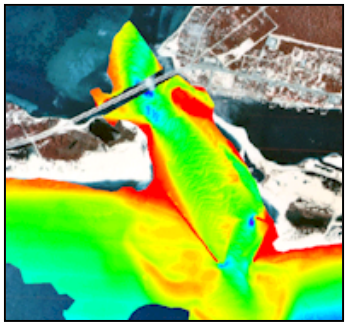
Using SBAS-A

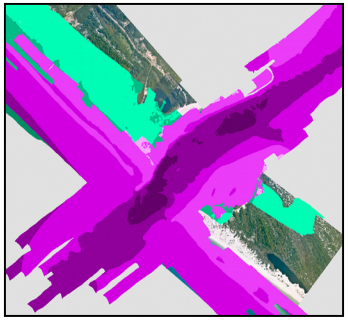
- Establishing a regional sediment budget is the primary function of the Regional Sediment Management GIS. A budget quantifies sediment erosion and accretion throughout the region caused by material processes. Sediment budgets lay the foundation for understanding a complex inlet and coastal system, under natural or engineered conditions.

- The SBAS-A is a tool that allows many local (project-level) sediment budgets to be characterized within one or more regional sediment budgets. Features of SBAS-A have been designed to facilitate creation and display of both the local and regional sediment budgets.

- SBAS-A is a software component designed for ArcGIS that is used to create and analyze sediment budgets for coastal inlets.

- SBAS-A facilitates calculating and displaying local and regional sediment budgets including single and multiple inlets, estuaries, bays, adjacent beaches, and through the watershed.





Sediment Budget Equation

$$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R =$$

Q source , Q sink = Import or Export to the cell

ΔV = Volume change within cell

P = Placement in the cell

R = Removal in the cell

Residual = cell surplus or deficit, 0 = balanced cell

Qsource and *Qsink* are the sources and sinks to the control volume, respectively, Δ*V* is the net change in volume within the cell, *P* and *R* are the amounts of material placed in and removed from the cell, respectively, and *Residual* represents the degree to which the cell is balanced. For a balanced cell, the residual is zero. For a region consisting of many contiguous cells, the budgets for individual cells must balance in achieving a balanced budget for the entire regional system.

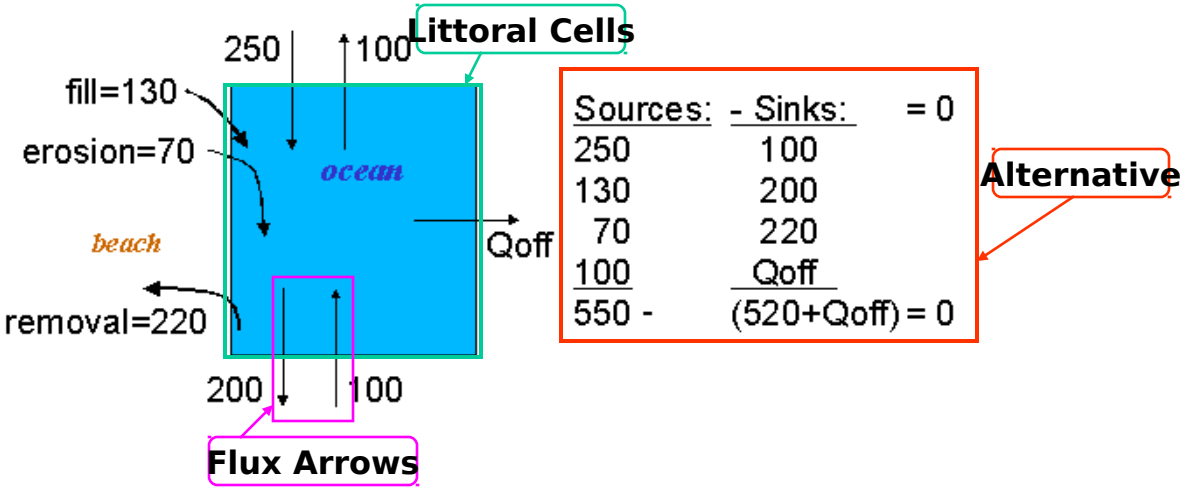
A **sediment budget** is a tallying of sediment gains and losses, or sources and sinks, within a specified control volume (or cell), or series of connecting cells, over a given time.

Sediment Budget Analysis System

Alternative: An alternative represents one set of assumed conditions for a particular sediment budget. Each Alternative has its own set of fluxes, cells, placements, and removals. Alternatives may be created to reflect different assumptions about sediment-transport magnitudes and pathways, and engineering activities within the budget, or a different time period as compared with the original formulation. At least one alternative must be created in the SBAS-A session. The alternative will save all values applied to cells and fluxes.

Littoral Cells: A collection of information describing similar physical, biological, and cultural characteristics within a particular area.

Flux: Flux values represent input and output of sediment into the cell. Each sediment budget cell requires eastward and westward transport rates.

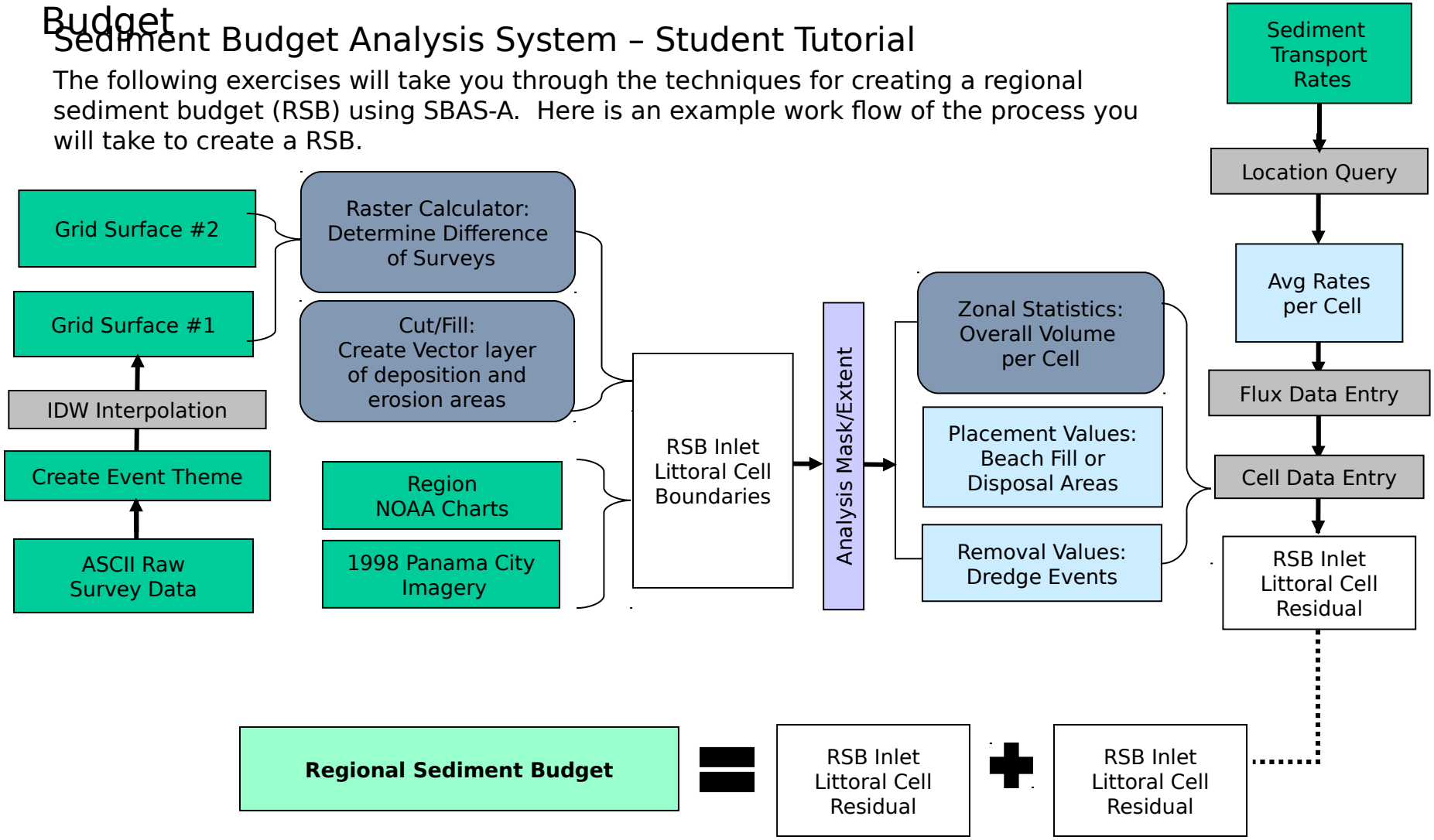


Sediment Budget Analysis System – Instructor Demonstration

Notes:

Sediment Budget Analysis System – Student Tutorial

The following exercises will take you through the techniques for creating a regional sediment budget (RSB) using SBAS-A. Here is an example work flow of the process you will take to create a RSB.



Exercise A: Creating Littoral Cells

Background

Littoral cells are defined by a collection of information describing similar physical, biological, and cultural characteristics within a particular area. The littoral cell inventory information can be in the form a map, database and text formats.

Using the ***Drawing Tools*** in ArcMap, graphic polygons can be drawn to represent cells areas. The boundaries of the littoral cells can be defined by either morphological features, such as, ebb and flood shoals, inlet throat, and adjacent beaches or political boundaries, such as, nautical charts and municipal boundaries for reference.

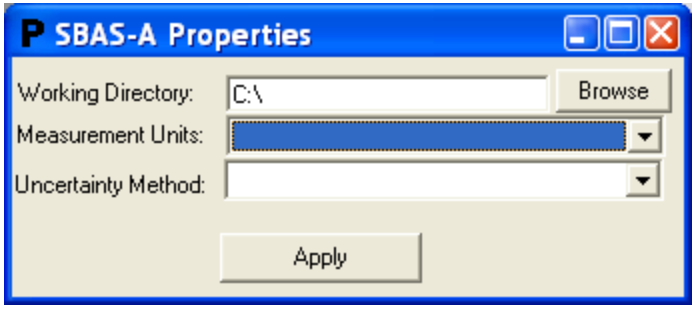
Goal

Using the ***Drawing Tools*** in ArcMap, you will be able to generate graphic polygons to represent littoral cell areas.

Objectives

1. Student will be able to know understand the use of Alternatives.
2. Students will be able to draw a graphic representation of Cell and Fluxes.

Exercise A: Creating Littoral Cells



☐Start a new ArcMap session, and **add all data** located in C:\Training\Data\SBAS-A. Zoom to the extent of the Study Area.

☐To begin a SBAS-A session, the SBAS-A toolbar must be loaded. From the **View** menu, select **Toolbars**. Click to turn on the **SBAS-A Toolbar**.
Before generating any littoral cells, we must set the application preferences.

☐From the **Alternative** menu, select **Set Preferences**.

☐Click the **Browse** button and locate to the **C:\Training\Data\SBAS-A** directory. Click **OK** then **Apply**. All shapefiles generated with the SBAS-A tool will be directed to the directory you select here.

Exercise A: Creating Littoral Cells

1. Sketching Littoral Cells

   - ☐ Using the **Draw** tools available in ArcMap, select the **Draw Polygon,** tool.

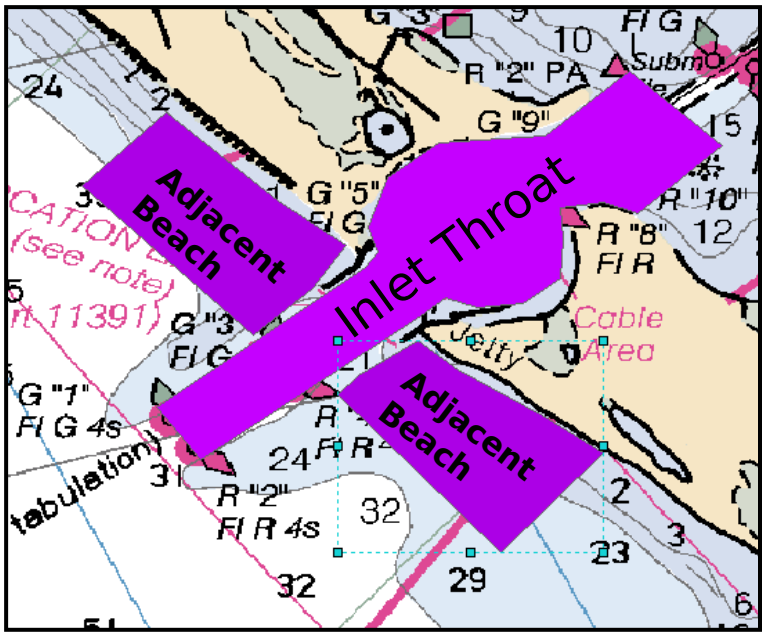
     Note: If this tool is not available, you may need to load the Draw toolbar.

   - ☐ Using the NOAA chart as a template, click to sketch a polygon graphic to represent the throat of the inlet. Double-click to end sketch.

   - ☐ Sketch two additional polygons alongside the inlet throat to represent adjacent beaches.

   - ☐ Select all graphics, by choosing the **Select All Elements** option from the **Edit** menu on the main toolbar.

2. From the **Budget** menu on the SBAS-A toolbox, select **Convert Graphics to New Layer.**



Exercise A: Creating Littoral Cells

3. If no Alternative currently exists, the tool will prompt you to create a new Alternative. The alternative will save all values associated with the sediment budget.

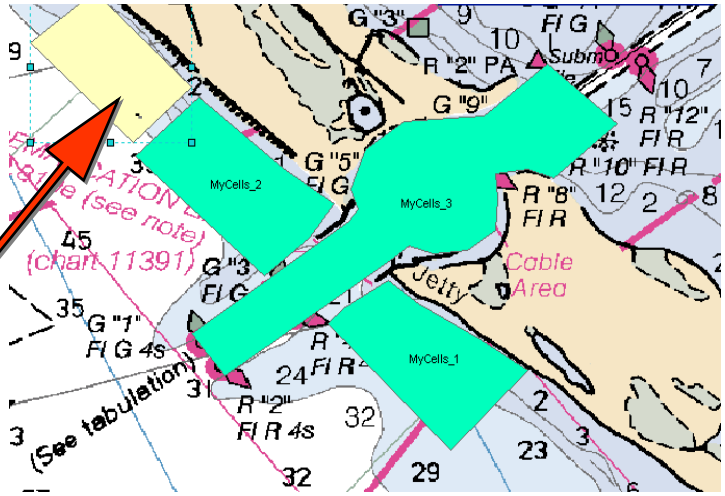
☐ Create a new alternative named '**Alt**'.

☐ Select, **Alt**, from the Alternative list.

☐ Click the **Create New Layer** button to continue the process.

☐ Enter **MyCells** as the name of the new layer. Click OK. This will convert the polygon graphics into a littoral cell layer and added the new layer to the Table of Contents. Layer symbology will also applied to the layer.

By default, when a littoral cell layer is created all residual values are set to zero. Therefore, all cell colors remain uniform until cell or flux values are edited.



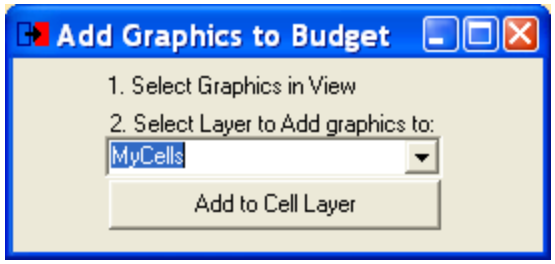
4. To add additional littoral cells after the layer was created, sketch the additional cells with the Draw Polygon, , tool.

☐ Draw another polygon alongside the existing adjacent beach polygons.

Exercise A: Creating Littoral Cells

5. Click to select the graphic. If more than one graphic was sketched, use the SHIFT key or choose **Select All Elements** from the **Edit** menu to select multiple graphics.

6. From the Budget menu on the SBAS-A toolbar, select the **Add Graphics to Layer** tool



   - ☐ Select **MyCells** layer as the layer to add graphics.
   - ☐ Click the **Add to Cell Layer** button to add the graphic(s) to the target layer.

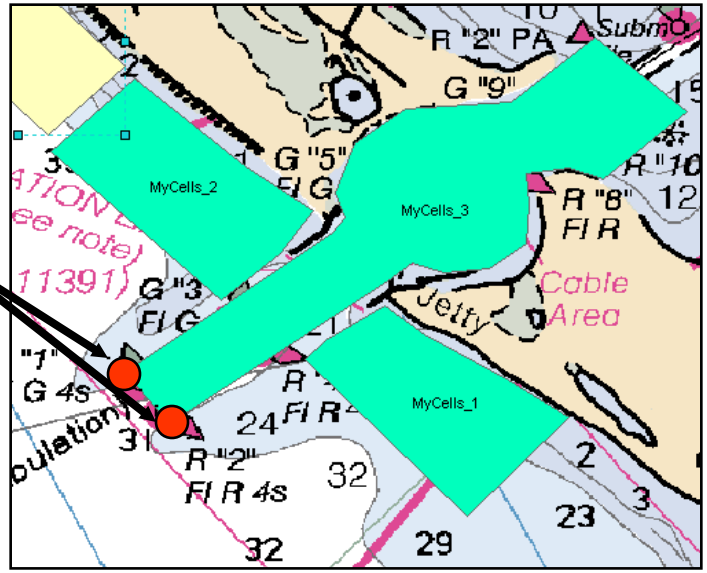
7. The design process of the Sediment Budget may also require reshaping existing littoral cells. If a user needs to resize or move a littoral cell, that already has been converted into a layer, the "Editor" toolbar must be visible and an Edit Session must be started.

   ☐ Start an Edit Session, by selecting the Editor menu from the Editor toolbar and choose **Start Editing**. Select your working directory from the list and click OK.

Exercise A: Creating Littoral Cells

- From the Editor toolbar, change the Task to **Extend/Trim Features** and set you target layer, **MyCells**, to the layer in need of reshaping.
- Once these settings are in place, use the Edit tool, , from the Editor toolbar to move or resize the dimensions of the target layer.
- Double-click to select the inlet throat cell. To move a vertex, click on a vertex and drag to new location. To add a vertex, right-click on the line and select Insert Vertex. For this exercise, move two vertices inland to make the inlet throat cell shorter.
- Save changes to the layer, by selecting the **Stop Editing** option from the Editor menu. When prompted, select Yes to save the changes.

  To completely remove a selected flux or cell from a Sediment Budget layer, select the layer in the Table of Contents and click the “Remove Cell/Fluxes” from the Edit menu on the SBAS-A toolbar. Be sure to be in an active Edit session. Do not delete any cells in this exercise.



Exercise A: Creating Littoral Cells

Exercise Summary

Littoral cells are defined by a collection of information describing similar physical, biological, and cultural characteristics within a particular area. Graphics polygons can be drawn on the map display to represent cells areas defined by:

- Morphological features: ebb and flood shoals, inlet throat, and adjacent beaches
- Political boundaries: nautical charts and municipal boundaries for reference. Cell divisions were placed at county and state lines.

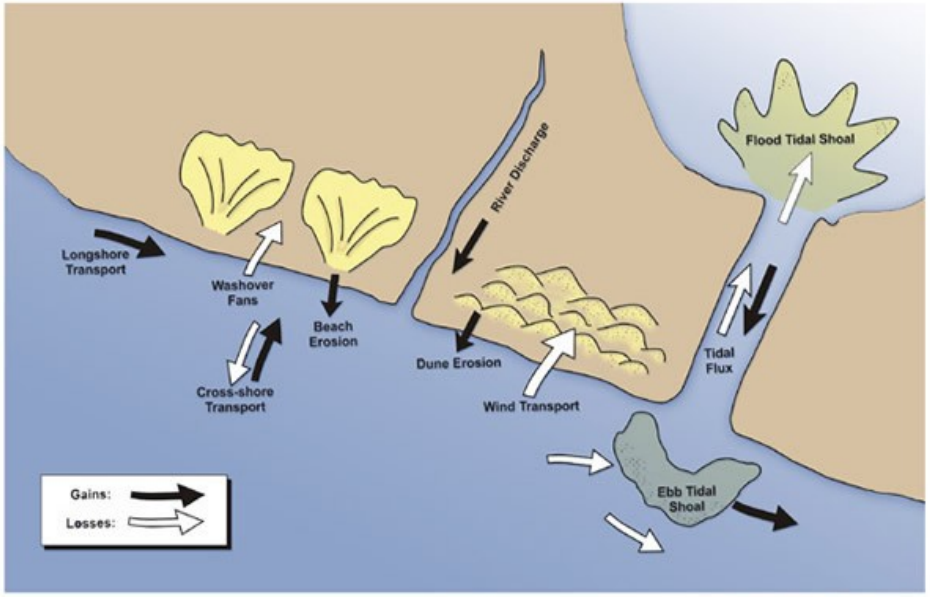
In future exercises, you will learn how to associate sediment placement and removal values to each of these littoral cells.

Exercise B: Creating Flux Layers

Background

Flux values represent input and output of sediment into the cell. Each sediment budget cell requires eastward and westward transport rates.

Using the ***Drawing Tools*** in ArcMap, graphic polylines can be drawn to represent the direction of sediment transport, or flux.



Goal

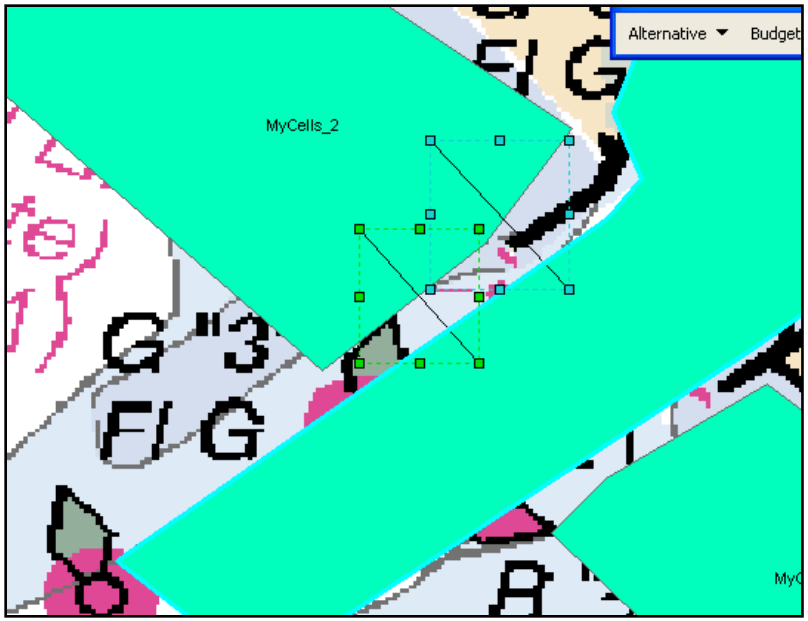
Using the ***Drawing Tools*** in ArcMap, you will be able to generate graphic polylines to represent flux direction.

Objectives

1. Students will be able to draw a graphic representation of fluxes.

Exercise B: Creating Flux Layers

Flux layers are created in a similar fashion as littoral cells. To create a flux layer, the **Draw Line** t is used . It is located on the Draw toolbar.



☐ Draw two polylines. One polyline beginning in the inlet throat cell (source) and ending in an adjacent beach cell (sink). The other beginning in the adjacent beach cell and ending in the inlet throat cell.

Polylines allow a line to have multiple vertices to “curve” around structures.

When graphic fluxes are initially drawn, arrowheads will not appear. They will be symbolized once they are converted into a layer.

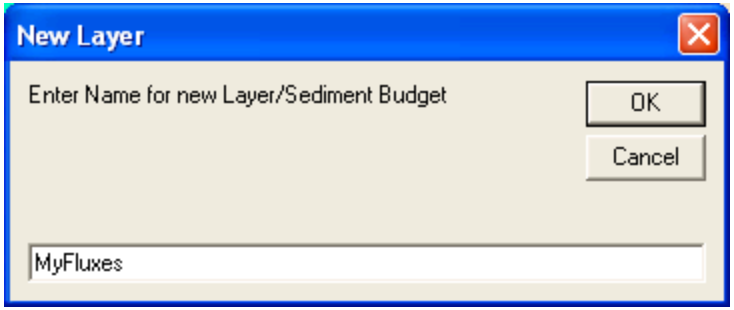
Exercise B: Creating Flux Layers

When all flux lines are drawn for the Sediment Budget, convert them to a layer using the same steps previously outlined for converting littoral cells. However, the flux option needs to be selected in order to convert the layer properly.

☐From the Edit menu, choose **Select All Elements**.

☐From the Budget menu, select **Convert Graphics to New Layer**.

☐ Since an alternative was already created with the Littoral Cell layer, select **Alt** from the Select Alternative menu.



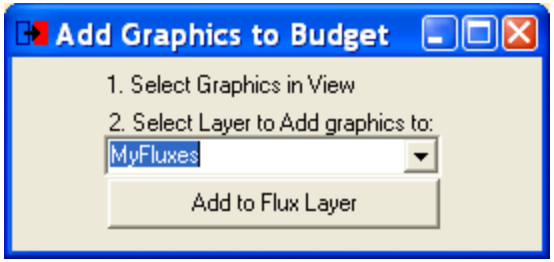
☐ Click the **Create New Layer** button.

☐Enter **MyFluxes** as the name of the new layer. Click OK. This will convert the polyline graphics into a flux layer and added the new layer to the Table of Contents. A layer symbology is also applied to the layer.

☐ Once the layer is added into the Table of Contents, the lines are transformed into arrows denoting sink and source values.

Exercise B: Creating Flux Layers

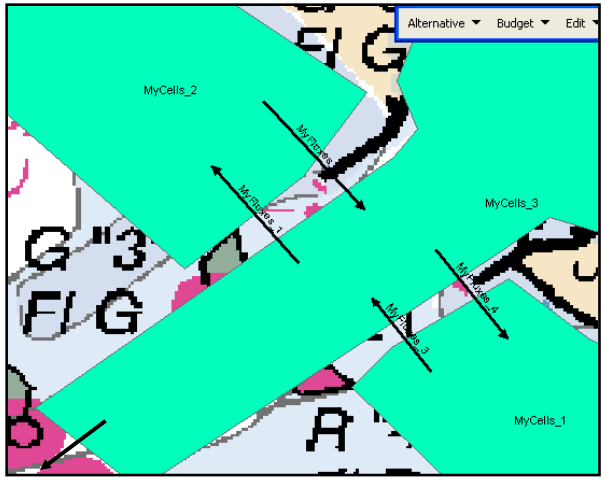
☐To add additional fluxes after the layer was created, sketch the additional flux arrows with the New Polyline, , tool.



☐Draw two polylines to connect the inlet throat cell to the other adjacent beach cell.

☐Draw one polyline to represent sediment flowing out of the inlet throat cell.

☐Click to select the graphics. Use the SHIFT key or choose **Select All Elements** from the **Edit** menu to select multiple graphics.



☐From the Budget menu on the SBAS-A toolbar, select the **Add Graphics to Layer** tool

☐Select **MyFluxes** layer as the layer to add graphics.

☐Click the **Add to Flux Layer** button to add the graphic(s) to the target layer.

Exercise B: Creating Flux Layers

Exercise Summary

Flux Layers represent the flow of sediment in and out of littoral cells. Using the tools provided in SBAS-A, you can draw graphics in the map display to symbolize sediment transport. In future exercises, you will associating sediment transport values to these flux arrows.

Gains and Losses of Sediment to the Littoral System

Now that the conceptual model has been designed for the area of interest, values can be attached to the Alternative to create a Regional Sediment Budget. Values can be obtained from a variety of sources, including data models (GENESIS), survey data (CHARTS), or dredging databases (Silent Inspector). Below are a list of data types that can be used to assist in the development of a budget.

Gains	Losses	Net
•Longshore transport into area •River transport •Sea cliff erosion •Onshore transport •Biogenic deposition •Wind transport onto the beach •Beach nourishment	•Longshore transport out of area •Offshore (or cross-shore) transport •Wind transport inland •Deposition in maintained navigation channels •Transport through submarine canyons •Solution and abrasion •Mining •Other anthropogenic causes	•Beach accretion or erosion (sand gains and losses)

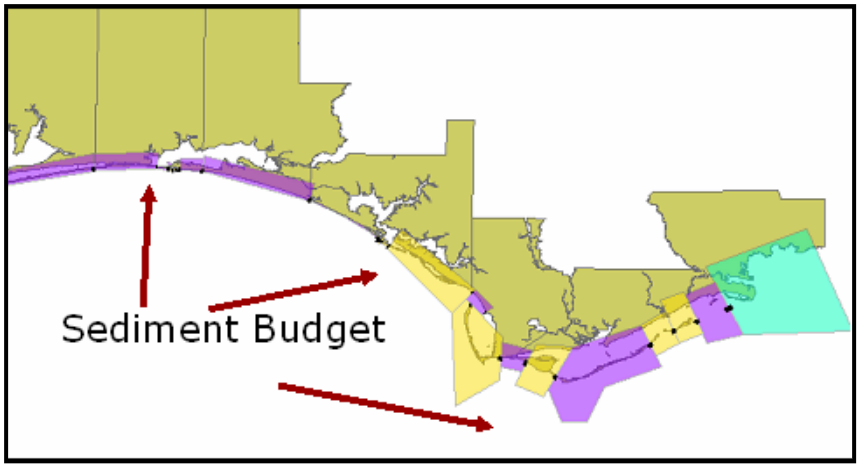
Residual Calculations

Residual represents the degree to which the cell is balanced. Residual is only zero is the cell is balanced. The sediment budget equation is:

$$\sum Qsource - \sum Qsink - \Delta V + P - R = \text{Residual}$$

Where Qsource and Qsink are the sources and sinks (transport rate values) to the control volume, respectively, dV is the net change in volume within the cell, P (Placement) and R (Removal) are the amounts of material placed in and removed from the cell, respectively. The SBAS-A extension automatically calculates the residual for each cell each time cell and/or flux values are updated.

This process of creating cell and flux areas and calculating the residual allows a regional budget to develop. Once a budget is established, it can be used as the baseline for scenarios. A GIS provides a data repository and the tools available to create and calculate values necessary to populate a sediment budget.



Exercise C: Determining Values to Cells and Fluxes

Background

To determine the volume of littoral cells, values can be computed from bathymetric datasets. The following exercise will use tools inherent in the ArcMap environment, as well as special functions available in the Spatial Analyst Extension to generate values for the sediment budget

Goal

Understand the process required to acquire values to create a Regional Sediment Budget.

Objectives

1. Using tools inherent in ArcGIS and eCoastal, students will be able to calculate values to be entered into the SBAS-A modules.
2. Using the SBAS-A Edit tools, students will be able to enter in values for littoral cells and fluxes.

Exercise C: Determining Values to Cells and Fluxes

1. To create a Cut/Fill layer, the Spatial Analyst extension is needed.

2. Use the Add Data tool and add the Pre and Post Storm lidar grid surfaces from the C:\Training\Data\SBAS-A directory.

3. From the Spatial Analyst menu, select ***Surface Analysis*** → ***Cut/Fill***.

4. Enter the Before (**PreStorm**) and After (**PostStorm**) Surfaces and click OK to create a new surface.

5. Cut/Fill creates a reclassified vector grid and adds the layer to the Table of Contents. A quick look at the layer, the user can quickly recognize area of gain and loss.

Cut/Fill

Cut/Fill summarizes the areas and volumes of change between two surfaces. It identifies the areas and volume of the surface that have been modified by the addition or removal of surface material.

By taking two surface rasters of a given area from two different time periods, the Cut/Fill function will produce a raster displaying regions of surface material addition, surface material removal, and areas where the surface has not changed over the time period. Negative volume values indicate areas tha
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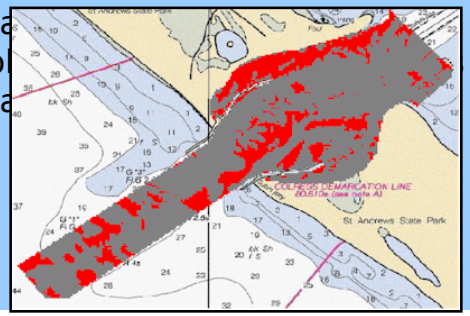
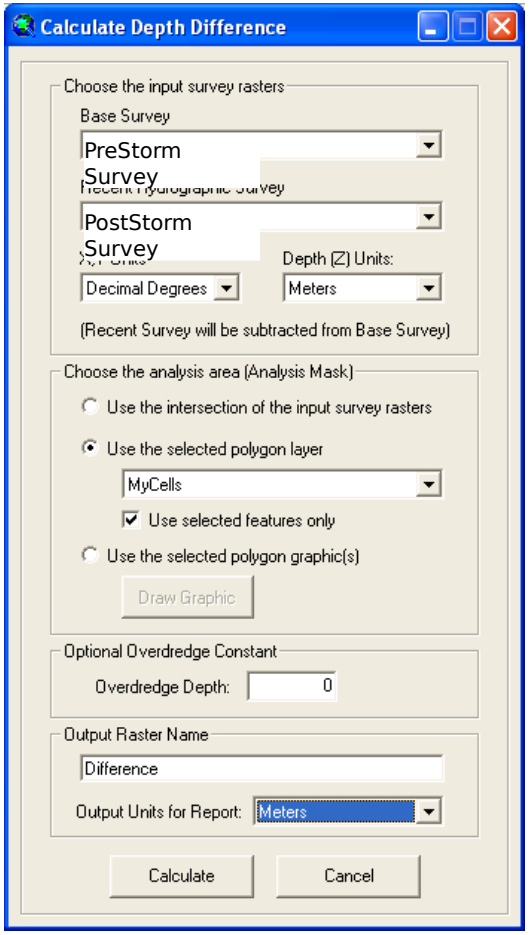


Exercise D: Calculate Volume Difference per Littoral Cell

1. Using the Calculate Depth Difference tool on the eGIS: Survey Tools toolbar we can calculate the change in volume for the selected littoral cell.

   - ☐ Select the inlet throat littoral cell with the seleool.
   - ☐ From the Surface menu on the Survey Tools toolbar, select Calculate Depth Difference.
   - ☐ Set the PreStorm Survey layer as the Base Survey.
   - ☐ Set the PostStorm Survey layer as the Recent Survey.
   - ☐ Set the XY Units as Decimal Degrees.
   - ☐ Select Meters for the Depth Units.
   - ☐ Check the second option for the analysis area – **Use the selected polygon layer**. Also, check the option to Use selected features only.
   - ☐ Select the **MyCells** layer.
   - ☐ Check **Use selected features** only.
   - ☐ Enter, **CellDV**, as name of the output raster.
   - ☐ Select meters are the output units.
   - ☐ Click the Calculate button.
   - ☐ From the Depth Difference Analysis Results window, record the value for the Total Difference: _____.



Exercise E: Entering Values to Cells

1. Having an ***Alternative*** already created, littoral cell values can be entered into the data entry module.

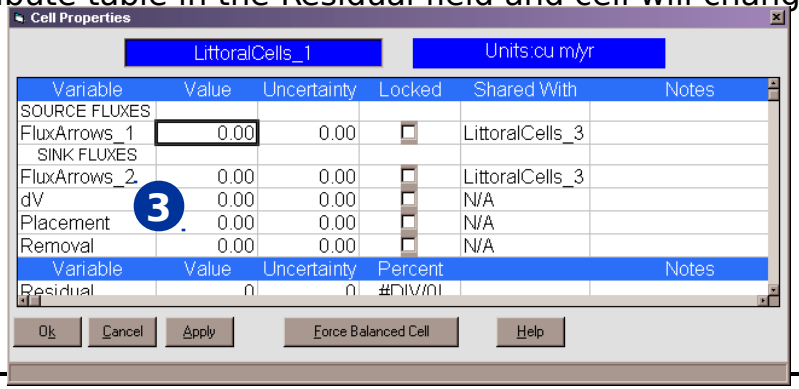
2. Select the Cell Layer in the Table of Contents. Click the ***Cell/Flux Edit*** tool, , and then select the desired littoral cell.

   ☐ Select the inlet throat littoral cell.

3. Click in the **dV cell in the SBAS spreadsheet and enter the** Total Difference value from the Depth Difference Analysis Results.

4. Click Apply to save value changes.

5. When values are entered into this spreadsheet and the Apply button is clicked, the residual value is posted in the layer's attribute table in the Residual field and cell will change color.



Incorporating Placement and Removal Values

If man-made processes, such as dredge events or beach fills, influence littoral cell areas, these variables can be added into the sediment budget equation. Through the use of the GUI interface, all values – dV, Placement and Removal can be entered and calculated for the cell using the SBAS-A's data entry module.

Exercise E: Entering Values to Cells

At times, there may be uncertainty when populating values to the littoral cells. SBAS-A allows you to set the uncertainty levels for your individual cells.

1. From the Edit Menu of the SBAS-A Toolbar, select **Set Confidence Levels**.

2. From the Select Layer combo box, select the **MyCells** layer. The available cells will be listed below.

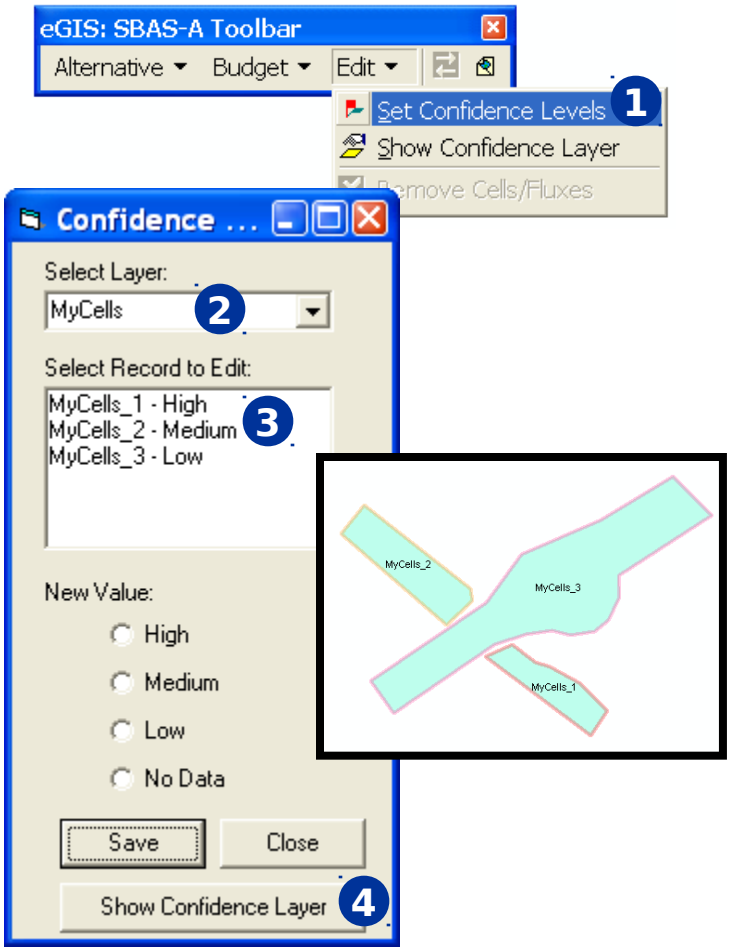
3. Click on the desired cell and set the confidence level.

   ☐ Click on **MyCells_1**, set the value to **High** and click **Save**.

   ☐ Click on **MyCells_2**, set the value to **Medium** and click **Save**.

   ☐ Click on **MyCells_3**, set the value to **Low** and click **Save**.

4. To display the confidence levels on the map, click the **Show Confidence Layer** button. The cells will be outlined in a confidence level color. You may need to turn off the NOAA chart to see this change.



Exercise E: Entering Values to Cells

Exercise Summary

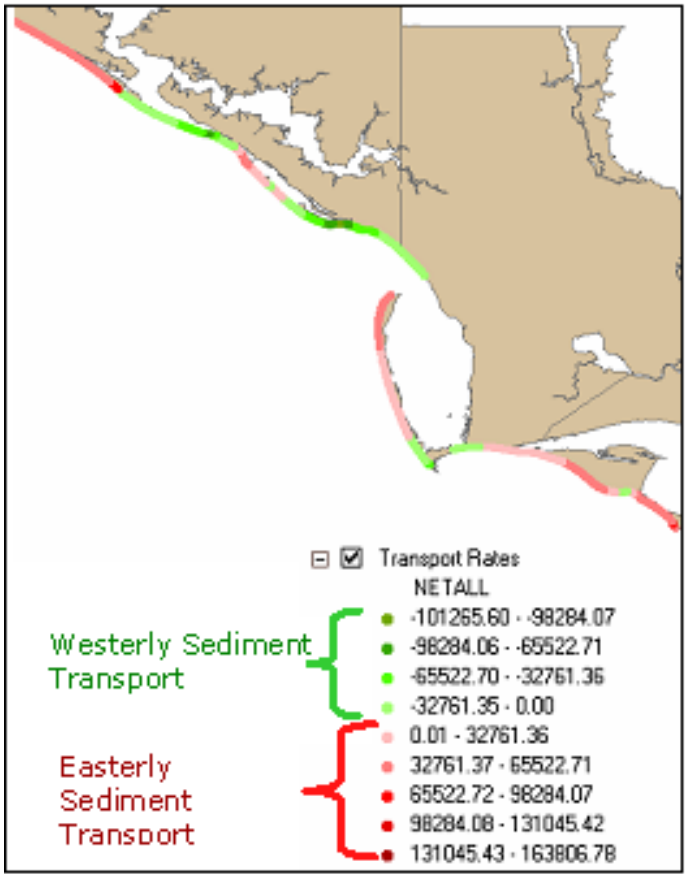
Volume computations between successive data sets were performed with multiple processes within the Spatial Analyst Extension and the Survey Tools. Once these values are computed they can be entered into the littoral cell data entry form available in SBAS-A. This form has options to allow the user to enter Placement, Removal and Volume Change values into the form. Once values are entered, a residual is automatically calcuated.

Exercise F: Entering Values to Fluxes

Background

Flux values represent input and output of sediment into the cell. Each sediment budget cell requires eastward and westward transport rates. Sediment transport rates produced from GENESIS model results can be imported into GIS.

As a graphical representation of flux values in the GIS environment, polylines can be drawn in the display and converted into a shapefile.



Sediment Transport Rates from GENESIS Model

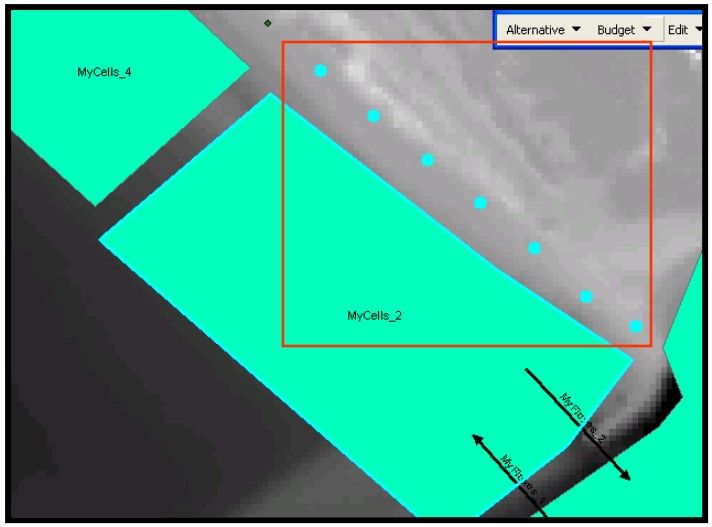
Exercise F: Entering Values to Fluxes

Calculating Flux Values

- The eastward transport rate can be obtained by averaging all the eastward transport estimates that intersect the littoral cell. The westward transport rate for each cell is determined in the same manner.

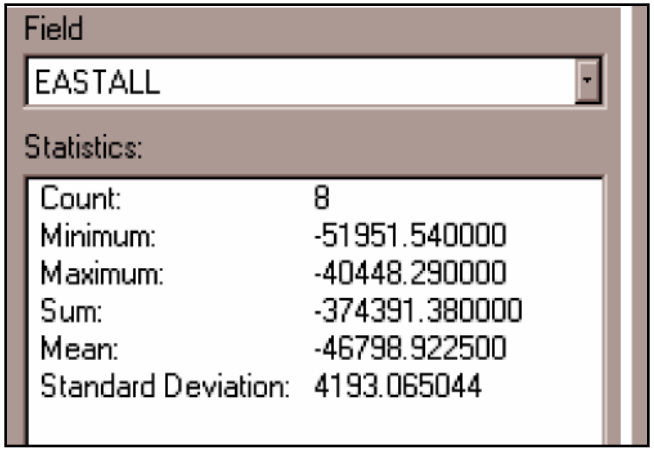
- First we will find all transport rates points that are contained by the littoral cell.

☐ Using the Select tool, select the Transport Rate points that are contained or immediately adjacent to the littoral cell just west of the inlet throat.



Exercise F: Entering Values to Fluxes

- ☐ Open the attribute table of the sediment **Transport Rates** Layer.
- ☐ View only the selected records by clicking on the **Selected** button at the bottom of the attribute table.
- ☐ Right-click on the EASTALL Column, select Statistics.
- ☐ Find the Mean value. This value will be used as the Easterly transport rate for the selected cell. Enter this value in the table below.
- ☐ Right-click on the WESTALL Column, select Statistics. Enter this value in the table below.
- ☐ Find the Mean value. This value will be used as the Westerly transport rate for the selected cell.



Fill in Values Here

MEAN EAST _____

MEAN WEST _____

- ☐ Close all windows.

Exercise F: Entering Values to Fluxes

1. Having an ***Alternative*** already created, flux values can be entered into the data entry module.

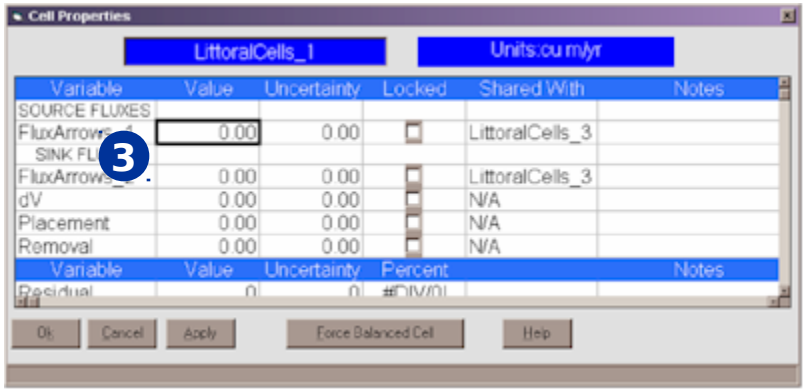
2. Select the **Cell Layer** in the Table of Contents. Using the ***Cell/Flux Edit*** tool, , click to select the cell. We will be editing the flux arrows that intersect the littoral cell.

   ☐Select the littoral cell **west** of the inlet throat.

3. Flux values can be entered with the data entry form.

   ☐Enter in the MEAN EAST value for the SINK data cell.

   ☐Enter the MEAN WEST value in the SOURCE data cell.



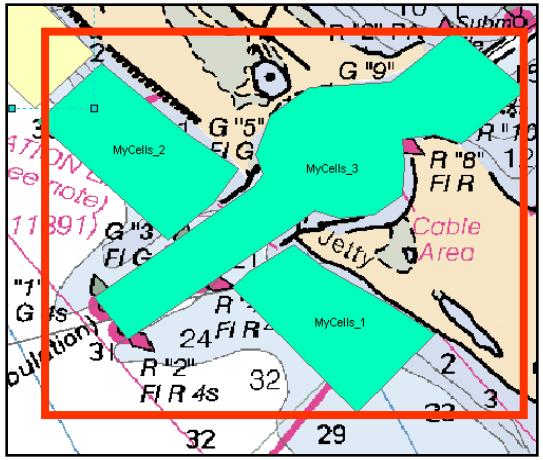
Exercise F: Entering Values to Fluxes

Exercise Summary

Flux values represent input and output of sediment into the cell. Each sediment budget cell requires eastward and westward transport rates. Sediment transport rates produced from GENESIS model results can be imported into the sediment budget as values associate with flux arrows. Users can attach these values by accessing the SBAS-A data entry forms for flux arrows.

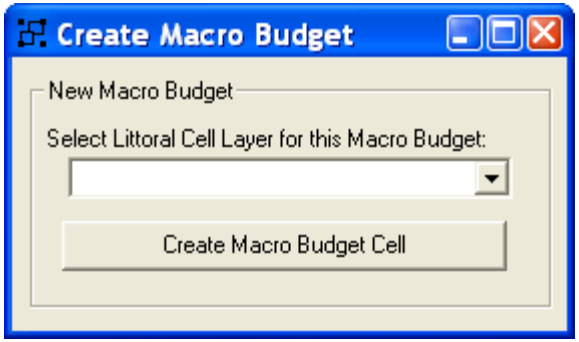
Exercise G: Creating Macro Budgets

A macro-budget provides validation of assumed quantities at the boundaries of a specified group of sediment budget cells. To construct a macro-budget, the user defines the budget for all cells that are bounded by assumed quantities. The macro-budget should balance (i.e., Residual = 0) if all assumed values are correct. A macro-budget out of balance (i.e., Residual=non-zero) implies that one or more assumed values must be revised to balance the budget.



☐Using the drawing tools, draw a polygon around the Panama City inlet cells.

☐From the **Budget** menu of the SBAS-A toolbar, select **Create Macro Budget**.



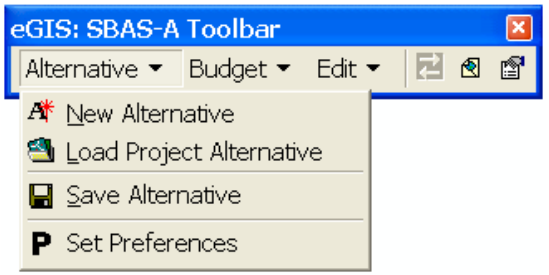
☐Select **MyCells** in the 'Select Littoral Cell Layer for this Macro Budget' option box.

☐Click the **Create Macro Budget Cell** button. Name the layer, **MyMacroBudget**. This action will calculate a grouped residual for the littoral cells that intersect the macro budget polygon. Macro Budgets are used to analyze an area on a regional scale.

Note: Once a Macro Budget cell is created, the child cells **cannot** be edited. To edit these cells, you must first delete the macro budget cell. To delete a cell, start an editing session (Editor Toolbar), select the macro cell, and choose '**Remove Cells/Fluxes**' from the Edit menu of the SBAS-A toolbar.

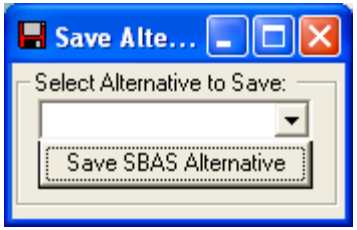
Exercise H: Saving/Loading SBAS-A Alternatives

The Alternative file holds all values entered into the SBAS-A cell and flux data entry forms. To retain this values for future use in other ArcMap documents or for use in the standalone version of SBAS, the alternative file **must** be saved.



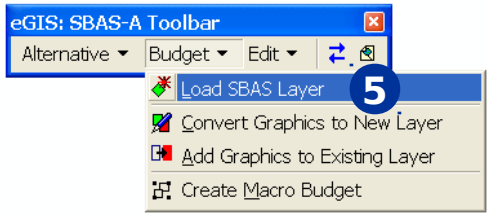
1. To save the alternative, from the "Alternative" menu select, "Save Alternative".

2. Select the desired alternative.
   - ☐ Select **Alt**



3. Click the "Save SBAS Alternative" button.
   - ☐ Save as **alt1.sbd** in C:\Training\Data\SBAS-A.

4. Close ArcMap and save as SBAS.mxd in C:\Training\MXD. Now, open new session of ArcMap.



5. From the Budget menu on the SBAS-A toolbar, select **Load SBAS Layer**.

6. Browse to select **MyCells.shp**, **MyFluxes.shp**, **MyMacroBudget.shp** in the C:\Training\Data\SBAS-A directory. SBAS-A will automatically load the layers and the respective alternative file (alt1.sbd).

7. If the alternative is not load, you will not be able to edit or view the values of your budget. To check which Alternative was used for the layer, open the layer's attributes and read the contents of the SBAS_FILE attribute.

Module Summary

Introduction to SBAS-A

This module provided instructions on the use of the tools available in the SBAS-A toolbar. Using a combination of the tools provided, and data stored in the geodatabase, users can create a sediment budget for the area of interest.